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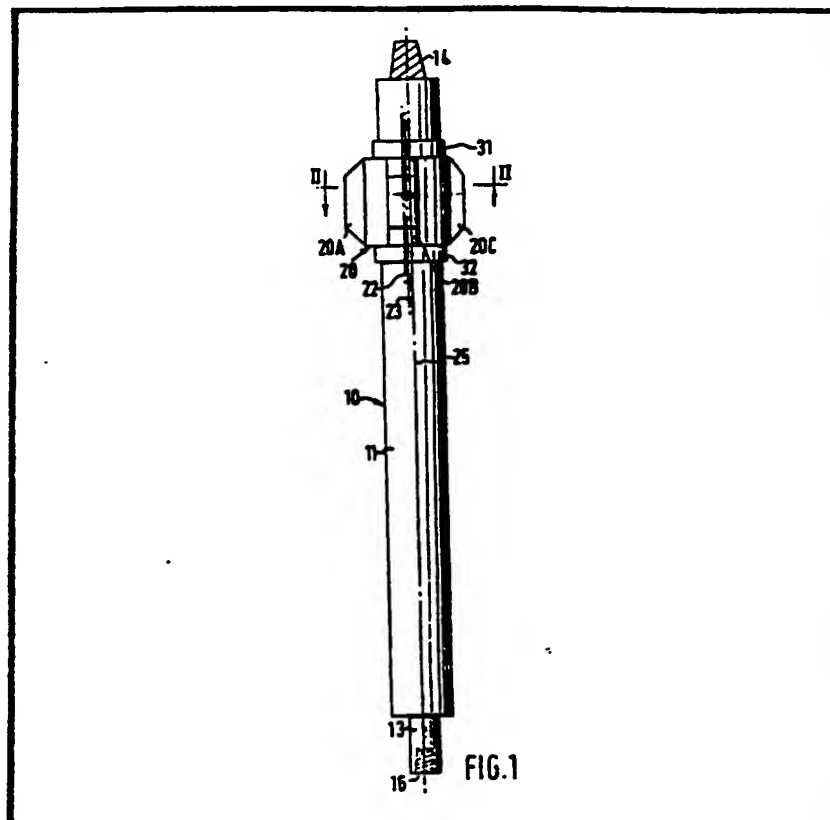
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## (54) Stabilizer/housing assembly and method for the directional drilling of boreholes

(57) The stabilizer/housing assembly  
for directional drilling of boreholes,  
includes a stabilizer 20 mounted  
either on the housing 11 of a  
downhole motor or on a pipe section  
(that is to be coupled to a downhole  
motor). The stabilizer 20 can rotate  
relative to the housing 11 between a

first end position wherein the  
stabilizer and the housing are  
eccentric and a second end position  
wherein they are concentric.

Directional drilling of boreholes is  
carried out by actuating a drill bit by  
means of the downhole motor, and  
simultaneously therewith rotating the  
drill string over periods that are  
preceded and succeeded by periods  
over which the drill string is not  
rotated.



GB 2 121 453 A

1/2

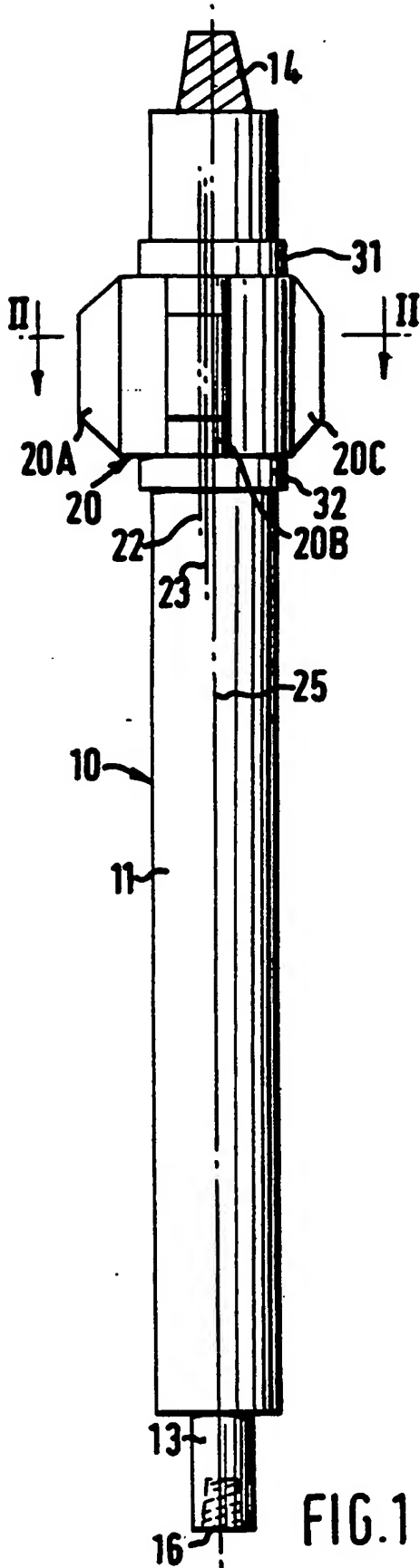


FIG. 1

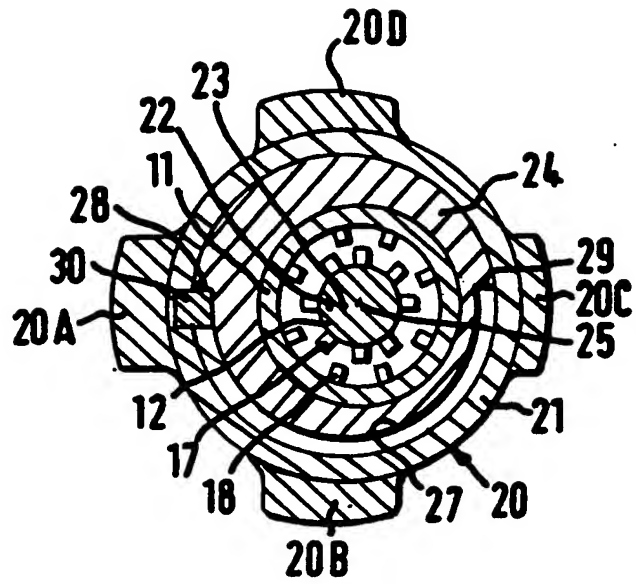


FIG. 2

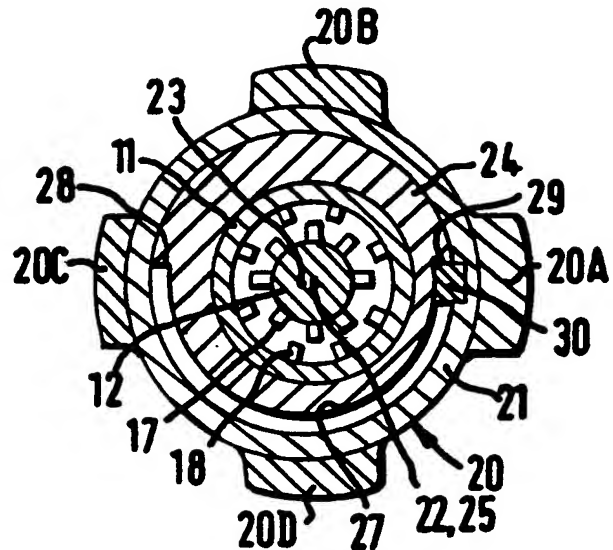


FIG. 3

2/2

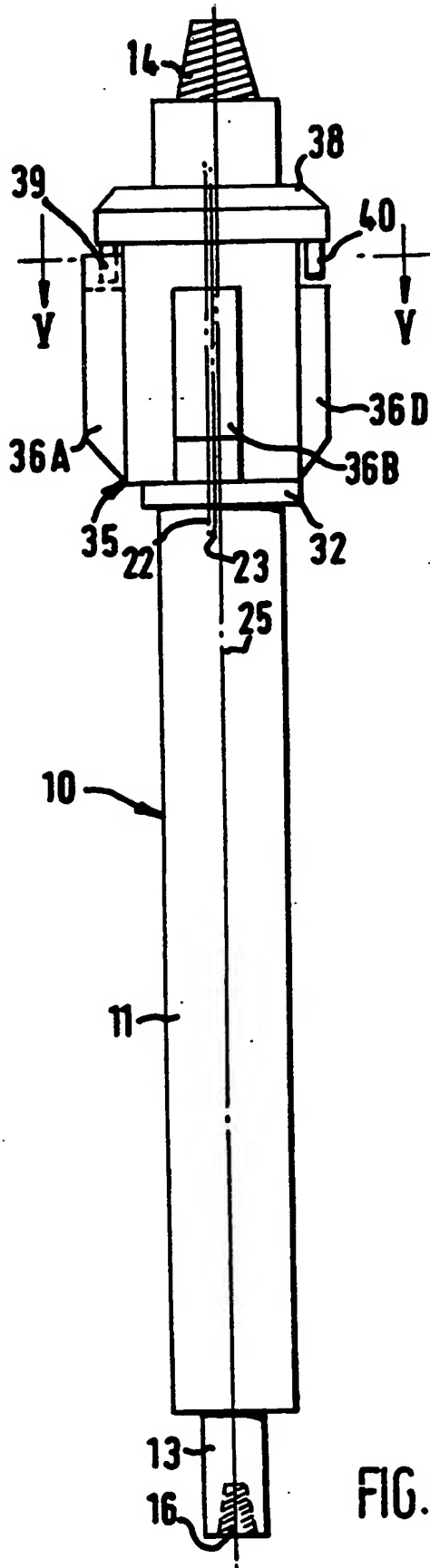


FIG. 4

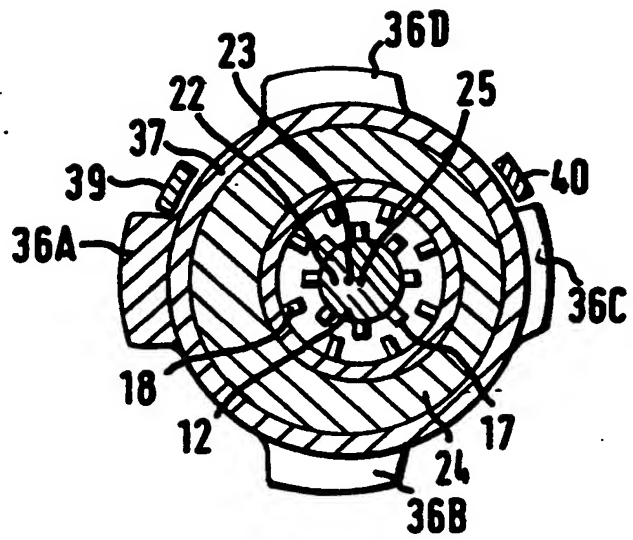


FIG. 5

## SPECIFICATION

## Stabilizer/housing assembly and method for the directional drilling of boreholes

The invention relates to the drilling of boreholes in underground formations in the search for valuable materials such as hydrocarbons. More in particular, the invention relates to a stabilizer/housing assembly and a method for the directional drilling of boreholes by using this assembly.

The expression "directional drilling of a borehole" is used in the specification and in the claims to refer to drilling a borehole that departs at will from the vertical or from any other direction.

A means known in the art suitable for the directional drilling of a borehole is the "variable bent sub". The variable bent sub is a pipe section, the deflection of which can be controlled by means of a remotely controlled servo system. The pipe section can be positioned between the upper end of a down-hole motor and the lower end of a drill string. When the pipe section is in the stretched position, a vertical borehole section is drilled. When it is required to drill a section that departs from the vertical or from any other direction, the deflection of the bent sub is adjusted in such a way that the central axis of the downhole motor intersects the central axis of the lower end of the drill string at a small angle. The variable bent sub is described in detail in French patent application 2,175,820 (filed: 18th March, 1972; inventor: Russell, M. K.).

A major disadvantage of the variable bent sub resides in the complexity of the remotely controlled servo system that is responsible for adjusting the deflection of the bent sub.

An object of the invention is to provide a stabilizer/housing assembly that forms a simple and reliable means for the directional drilling of a borehole, and which means does not include a complex control or adjusting system. A further object of the invention is to provide a simple method for directionally drilling of boreholes by using the stabilizer/housing assembly.

The stabilizer/housing assembly according to the invention includes a housing and a stabilizer, the stabilizer comprising a sleeve and a plurality of blades that project outwards from the sleeve, the sleeve being mounted on the housing in such a way that the stabilizer can be rotated relative to the housing between a first end position wherein the stabilizer is eccentric to the housing, and a second end position wherein the stabilizer is concentric to the housing, and vice versa.

The housing of the assembly may be formed either by a pipe section (sub) provided with connector means for including the pipe section in a drill string, or by the housing of a downhole motor, which motor is provided with an output shaft and with connector means for connecting the motor to the lower end of a drill string.

The method according to the invention for directional drilling of a borehole by means of the

stabilizer/housing assembly according to the invention consists of lowering a drill string assembly including a drill string, a drill bit and the stabilizer/housing assembly in the borehole, rotating the axially loaded drill bit relative to the drill string by means of a downhole motor, and simultaneously therewith rotating the drill string over periods that are preceded and succeeded by selected periods during which the drill string is not rotated.

The expression "central axis of a stabilizer" as used in the specification refers to the central axis of a surface of revolution that envelops the blades of the stabilizer.

The invention will now be explained by way of example in more detail with reference to the drawings, wherein:

Figure 1 shows a side-view of a stabilizer/housing assembly according to the invention, wherein the stabilizer is in a position that is eccentric to the housing;

Figure 2 shows a cross-section of Figure 1 over the line II—II, drawn to a scale larger than the scale of Figure 1;

Figure 3 shows the cross-section of Figure 2, but wherein the stabilizer is shifted to a position that is concentric to the housing;

Figure 4 shows a side-view of an alternative embodiment of the invention; and

Figure 5 shows a cross-section of Figure 4 over the line V—V, drawn to a scale larger than the scale of Figure 4.

Reference is made to Figure 1 showing a side-view of a stabilizer/housing assembly for directional drilling of boreholes and to Figure 2, showing a cross-section of Figure 1 over the line II—II and drawn to a scale larger than the scale of Figure 1. In the embodiment of the invention shown in Figures 1 and 2, the housing of the stabilizer/housing assembly is formed by the housing 11 of the hydraulic turbine 10. The turbine further includes a rotor 12, and an output shaft 13 connected to the rotor 12. The upper end of the housing 11 is provided with upper connector means in the form of an external tapered thread 14 for connecting the turbine 10 to the lower end of a drill string (not shown) and the output shaft 13 is provided with an internal tapered thread 16 for connecting a drill bit (not shown) to the output shaft. The rotor 12 is provided with rotor blades 17 and the turbine housing 11 is provided with stator blades 18. As this type of turbine is known per se, no constructional details thereof (such as seals and bearings) are shown.

The stabilizer/housing assembly further includes a stabilizer 20 carried by the housing 11 of the hydraulic turbine 10. The stabilizer 20 consists of a sleeve 21 and four blades 20A, 20B, 20C and 20D that are arranged eccentrically on the sleeve 21. Thus the central axis 22 of the stabilizer is arranged eccentric to the central axis 23 of the sleeve 21. This latter axis, however, coincides with the central axis of the cylindrical body 24 that is eccentrically mounted on the

Stator  
Blades  
Rotor

housing 11 (with the central axis 25). The sleeve 21 of the stabilizer is rotatably mounted on the cylindrical body 24.

- 5 The cylindrical body 24 is provided with a groove 27 that extends between a first shoulder 28 and a second shoulder 29 over an arc that is somewhat larger than 180°. The sleeve 21 carries a spline 30 that co-operates with the groove 27 in such a way that the sleeve 21  
10 together with the blades 20A, 20B, 20C and 20D can rotate relative to the body 24 and to the housing 11 over an arc of 180° between the shoulders 28 and 29. Axial displacement of the sleeve 21 is prevented by rings 31 and 32 that are connected to the housing 11 of the turbine 10.

- Figures 1 and 2 show the stabilizer 20 in the eccentric position thereof relative to the housing 11 of the turbine 10. In this end position of the  
20 stabilizer 20, the central axis 22 of the stabilizer is parallel to the central axis 25 of the turbine housing 11, and the central axis 23 of the cylindrical body 24 is positioned halfway between the central axis 25 of the turbine housing 11 and the central axis 22 of the stabilizer 20. By rotating the stabilizer 20 about the cylindrical body 24, the central axis 22 of the stabilizer will revolve round the central axis 23 of the cylindrical body 24 until the rotation is stopped by the spline 30  
25 contacting the second shoulder 29 of the groove 27. In this end position of the stabilizer (see Figure 3), the axes 22 and 25 coincide, and the stabilizer 20 is in the concentric position relative to the housing 11 of the turbine 10.

- 30 For drilling a section of a borehole with the stabilizer/housing assembly shown in Figures 1—3 of the drawings, a drill bit (not shown) is connected to the output shaft 13 and the turbine carrying the stabilizer is connected to the lower end of a drill string (not shown). Thereupon, the drill string assembly, including the drill string and the turbine is lowered in the borehole until the drill bit rests on the bottom of the borehole. Drilling fluid is then pumped through the interior  
40 of the drill string to drive the turbine 10 to rotate the drill bit and a predetermined amount of weight on bit is applied.

- Depending on the position of the stabilizer with respect to the housing of the turbine, the section that is subsequently being drilled (which section forms an extension of the existing borehole) will either be in the direction of the borehole, or deviate therefrom. It will be appreciated that by "the direction of the borehole" is meant the direction of the central axis of the lower end of the borehole (that is at the location where the drill bit is on the bottom of the hole).

- It will be appreciated that the stabilizer will be brought into the concentric position thereof (and also stay in this position) by rotating the drill string in the direction wherein the second shoulder 29 of the groove 27 is in contact with the spline 30 of the stabilizer sleeve 21 (see Figure 3). This concentric position will also be  
65 maintained when—simultaneously with the

rotation of the drill string—the rotary bit (not shown) is activated by the turbine 10.

- The rotation of the drill string (which rotation originates from the rotation of the rotary table of the drilling rig) is transferred to the stabilizer 20  
70 (see Figures 1 and 3) via the external tapered thread 14, the turbine housing 11, the cylindrical body 24, the second shoulder 29 and the spline 30.

- 75 When the stabilizer 20 is operated in the borehole in its concentric position (see Figure 3), the blades 20A—D thereof centralize the turbine in the borehole. The drill bit will then be guided in the direction of the borehole and thus the section that forms the extension of the borehole will be drilled in the direction of the borehole.

- When the drill string is not rotated over the periods that the drill bit is activated by the turbine, the reaction torque exerted on the housing of the turbine will rotate the housing in a direction such that the first shoulder 28 of the groove 27 will make contact with the spline 30 of the sleeve 21 of the stabilizer 20. The stabilizer 20 will then be in its eccentric position (see Figure 2) as a result  
90 whereof the central axis of the drill bit will be inclined relative to the central axis of the borehole, and drilling of the extension of the hole by the action of the turbine whilst the drill string is not rotated will result in a borehole section having a direction that deviates from the direction of the borehole. During drilling, the inclination of the axis of the bit with respect to the axis of the borehole extension increases, and as a result thereof a curved section is being drilled.

- 100 Since the position of the stabilizer with respect to the housing can be controlled by rotating the drill string or keeping it immobile, the central axis of the bit can be manoeuvred either in a position wherein it coincides with the central axis of the borehole, or in a position wherein it is inclined to the central axis of the borehole, respectively. Thus the stabilizer/housing assembly allows directional drilling of the borehole by rotating the axially loaded drill bit by means of the turbine, and actuating the drill string to rotate the string over periods that are preceded and followed by selected periods over which the drill string is not rotated.

- It will be appreciated that the direction of the planes in which curved sections of the borehole are being drilled can be monitored by logging equipment that is carried by the lower end of the drill string. Such equipment that is applied for measuring inclination and azimuth of the borehole is known per se and does not require any detailed description. The desired azimuth of the borehole section that is being drilled is controlled by adjusting the angular position of the upper end of the non-rotating drill string. Such adjustment is obtained by a rotational displacement of the rotary table over an angle that results in a position of the body 24 (see Figure 2) on the turbine housing 11, wherein the plane of symmetry of the blades 20A and 20C of the stabilizer coincides  
125 with the plane wherein the central axis of the

curved borehole section to be drilled should be situated.

The invention is not restricted to the construction described with reference to Figures 2 and 3, wherein the shoulders 28 and 29 are positioned such that the stabilizer 20 can rotate over 180° with respect to the housing 11. If desired, the cylindrical body may be constructed such that the shoulders limit the stabilizer rotation to a suitable angle other than 180°.

Reference is now made to Figure 4, showing a side-view of a stabilizer/housing assembly according to the present invention, wherein the stabilizer construction differs from the stabilizer design shown in Figures 1—3 of the drawings.

Figure 5 shows a cross-section of Figure 4 over the line V—V. The scale of Figure 5 is larger than the scale of Figure 4.

Those elements of the assembly shown in Figures 4 and 5 that are equivalent to the elements shown in Figures 1—3 are indicated by the same reference numerals.

The stabilizer 35 has four blades 36A, 36B, 36C and 36D mounted on a sleeve 37. The stabilizer is rotatably arranged on the cylindrical body 24 that is mounted on the turbine housing 11 in such a manner that the central axis 23 of this body is halfway between the central axis 25 of the housing 11 and the central axis 22 of the stabilizer 35 when the latter is in the eccentric position thereof (as shown in the drawings).

Axial displacement of the stabilizer 35 with respect to the housing 11 of the turbine 10 is prevented by the rings 32 and 38 that are mounted on the housing 11. The upper ring 38 is provided with two stops 39 and 40 arranged to co-operate alternately with the two sides of the upper end of the blade 36A. The blades 36B, 36C and 36D are shorter in length and allow rotation of the sleeve about the body 24. It will be appreciated that when the stabilizer 35 is rotated in anti-clockwise direction from the eccentric position thereof shown in Figures 4 and 5, this rotation will be stopped by the stop 40 when the stabilizer is in the concentric position (which position corresponds with the stabilizer position of the assembly shown in Figure 3 of the drawings).

The assembly shown in Figures 4 and 5 is operated in the same manner as described with reference to the assembly shown in Figures 1—3 of the drawings.

The invention is not restricted to a stabilizer/housing assembly wherein the housing is formed by the housing of a turbine as shown in Figures 1—3 and in Figures 4 and 5. If desired, the housing may be formed by a pipe section that is provided with a first connector means to connect the pipe section to the upper connector means of a turbine and with a second connector means to connect the pipe section to the lower end of a drill string. For directional drilling of a borehole a drill string assembly including a drill string, the stabilizer/pipe section assembly, a turbine and a drill bit is lowered in the borehole.

To drill a borehole, the axially loaded drill bit is rotated relative to the drill string by means of the turbine, and simultaneously therewith the drill string is rotated over periods that are preceded and succeeded by periods during which the drill string is not rotated. In this manner the successive sections of the hole that is being drilled, will alternately be curved and straight, and this allows the operator to direct the borehole to a desired target area in the subsurface formation.

If desired, the stabilizer/housing assembly shown in Figures 1—3 as well as the stabilizer/housing assembly shown in Figures 4 and 5 may be used in combination with a drill string that carries a concentric stabilizer on or near the lower end thereof at some distance above the turbine. When applying a relatively long turbine housing in the assembly, it is sometimes advisable to mount the concentric stabilizer near the upper end of the turbine housing and to arrange the stabilizer of the assembly at some distance therebelow.

The invention is not restricted to stabilizers having four straight blades. The blades may be helically shaped in clockwise or counter-clockwise direction and the number of blades should be such that the stabilizer can guide the sleeve in a borehole. In addition thereto, the outer surface of the blades may be provided with wear resistant inserts to reduce the wear of the blades.

Further the invention is not restricted to the use of a particular type of down-hole motor in the assembly. Any type of down-hole motor known in the art such as a vane motor, or a Moineau motor (also referred to as Mono-motor) or an electric motor may be used.

#### Claims

1. Stabilizer/housing assembly for use in directional drilling of boreholes in subsurface formations, which assembly includes a housing and a stabilizer, the stabilizer comprising a sleeve and a plurality of blades that project outwards from the sleeve, the sleeve being mounted on the housing in such a way that the stabilizer can be rotated relative to the housing between a first end position wherein the stabilizer is eccentric to the housing, and a second end position wherein the stabilizer is concentric to the housing, and vice versa.

2. Stabilizer/housing assembly according to claim 1, wherein the housing is formed by the housing of a downhole motor that is provided with an output shaft and with connector means for connecting the motor to the lower end of a drill string.

3. Stabilizer/housing assembly according to claim 1, wherein the housing is formed by a pipe section that is provided with connector means for including the pipe section in a drill string assembly.

4. Stabilizer/housing assembly according to any one of the claims 1—3, wherein the stabilizer is rotatably mounted on a cylindrical body that is eccentrically mounted on the housing.

5. Stabilizer/housing assembly according to claim 4, including a spline cooperating with a groove extending between two shoulders, the spline being in contact with a shoulder in each of the two end positions of the stabilizer.
6. Stabilizer/housing assembly according to claim 5, wherein the groove extends over part of the outer surface of the cylindrical body, and wherein the spline is connected to the interior of the sleeve.
7. Stabilizer/housing assembly according to claim 5, wherein the groove extends over part of the interior of the sleeve and wherein the spline is mounted on the cylindrical body.
8. Stabilizer/housing assembly according to any one of the claims 1—4, wherein the housing is provided with two stops that cooperate with at least one of the blades of the stabilizer, the blade being in contact with a stop in each of the two end positions of the stabilizer.
9. Stabilizer/housing assembly according to any one of the claims 1—8, wherein the stabilizer

can be rotated between the two end positions over an angle of 180°.

10. Stabilizer/housing assembly for directional drilling of boreholes in subsurface formations substantially as described with reference to Figures 1—3, and Figures 4 and 5 of the drawings.
11. Method for directional drilling of a borehole wherein a drill string assembly including a drill string, a drill bit and the stabilizer/housing assembly according to claim 1 is lowered in the borehole, and the axially loaded drill bit is rotated relative to the drill string by means of a downhole motor, and wherein simultaneously with the rotation of the axially loaded drill bit the drill string is rotated over periods that are preceded and succeeded by selected periods over which the drill string is not rotated.
12. Method for directional drilling of boreholes substantially as described with reference to Figures 1—3 of the drawings.